

The New England Journal of Medicine

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VOLUME 338

JUNE 25, 1998

NUMBER 26



AN OUTBREAK OF MULTIDRUG-RESISTANT PNEUMOCOCCAL PNEUMONIA AND BACTEREMIA AMONG UNVACCINATED NURSING HOME RESIDENTS

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ABSTRACT

Background Outbreaks of pneumococcal disease are uncommon and have occurred mainly in institutional settings. Epidemic, invasive, drug-resistant pneumococcal disease has not been seen among adults in the United States. In February 1996, there was an outbreak of multidrug-resistant pneumococcal pneumonia among the residents of a nursing home in rural Oklahoma.

Methods We obtained nasopharyngeal swabs for culture from residents and employees. *Streptococcus pneumoniae* isolates were serotyped and compared by pulsed-field gel electrophoresis. A retrospective cohort study was conducted to identify factors associated with colonization and disease.

Results Pneumonia developed in 11 of 84 residents (13 percent), 3 of whom died. Multidrug-resistant *S. pneumoniae*, serotype 23F, was isolated from blood and sputum from 7 of the 11 residents with pneumonia (64 percent) and from nasopharyngeal specimens from 17 of the 74 residents tested (23 percent) and 2 of the 69 employees tested (3 percent). All the serotype 23F isolates were identical according to pulsed-field gel electrophoresis. Recent use of antibiotics was associated with both colonization (relative risk, 2.3; 95 percent confidence interval, 1.3 to 4.2) and disease (relative risk, 3.6; 95 percent confidence interval, 1.2 to 10.8). Only three residents (4 percent) had undergone pneumococcal vaccination. After residents received pneumococcal vaccine and prophylactic antibiotics, there were no additional cases of pneumonia, and the rates of carriage decreased substantially.

Conclusions In this outbreak a single pneumococcal strain was disseminated among the residents and employees of a nursing home. The high prevalence of colonization with a virulent organism in an unvaccinated population contributed to the high attack rate. Clusters of pneumococcal disease may be underrecognized in nursing homes, and wider use of pneumococcal vaccine is important to prevent institutional outbreaks of drug-resistant *S. pneumoniae* infection. (N Engl J Med 1998;338:1861-8.)

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PNEUMOCOCCAL disease accounts for more deaths than any other vaccine-preventable bacterial disease.¹ Among the elderly, the case fatality rates for bacteremia approach 40 percent.^{2,3} Most cases are sporadic, and during the antibiotic era outbreaks caused by a single pneumococcal serotype have been rare, occurring mainly in institutions such as hospitals,⁴ military camps,^{5,6} shelters,^{7,8} jails,⁹ day-care centers,^{10,11} and nursing homes.^{12,13}

Since 1990, drug-resistant pneumococcal strains have become increasingly common in the United States,¹⁴⁻¹⁸ making the selection of empirical treatment for pneumococcal infections difficult.^{15,18-20} Drug-resistant infections have also been associated with certain institutional settings, particularly day-care centers,²¹⁻²⁴ hospitals,²⁵⁻³⁰ and a pediatric long-term care facility.³¹ Despite the continuing emergence of drug resistance, epidemics of drug-resistant pneumococcal disease have not been previously reported among adults in the United States. We investigated an outbreak of multidrug-resistant *Streptococcus pneumoniae* serotype 23F among unvaccinated nursing home residents in a rural Oklahoma community (population, 18,000) where antimicrobial resistance among *S. pneumoniae* isolates had not previously been observed. We studied factors associated with colonization and disease, assessed modes of transmission, and evaluated the effect of control measures.

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METHODS

Background

On February 16, 1996, the Centers for Disease Control and Prevention received notification that three residents of a long-term care facility had been hospitalized with pneumococcal bacteremia within a five-day period; two had died of rapidly progressing illness that did not respond to intravenous cefuroxime therapy. Initial testing indicated that all isolates had an intermediate level of susceptibility to penicillin and cefotaxime (minimal inhibitory concentration, 1.0 μg per milliliter for both by the E test), were resistant to trimethoprim-sulfamethoxazole and erythromycin, and were susceptible only to vancomycin. The clinical microbiology laboratory of the community hospital had routinely screened all sterile-site *S. pneumoniae* isolates for antimicrobial resistance³² since January 1995, but no resistant isolates had been identified previously.

Epidemiologic Investigation

We defined a case as an instance of radiographically documented pneumonia occurring in a resident of the nursing home between February 6 and February 20, 1996 (the outbreak period). A carrier was defined as a resident without lower respiratory illness from whom the outbreak strain was isolated by nasopharyngeal-swab culture. To determine the extent of spread of the outbreak strain within the nursing home, we obtained nasopharyngeal swabs for culture from residents and employees before interventions were carried out and evaluated the effect of the interventions in two follow-up surveys. To identify factors associated with colonization and disease in a retrospective cohort study, we compared attack rates among colonized residents with those among noncolonized residents and attack rates among residents who had pneumonia with those among asymptomatic residents. Information from medical charts was obtained with a standardized form. Five residents who had died between February 1 and February 17 were excluded from the study because no diagnostic testing was performed. One patient with pneumonia was excluded because a penicillin-sensitive strain of *S. pneumoniae* serotype 16 was isolated from his sputum culture. To assess the presence of the outbreak strain in the community, we obtained nasopharyngeal cultures from children 2 to 59 months of age in two day-care centers and the county health-department clinic.

Laboratory Methods

Nasopharyngeal secretions were obtained with sterile calcium alginate swabs, inoculated directly onto blood-agar plates, and incubated overnight. *S. pneumoniae* isolates were serotyped with the quellung reaction and tested for antimicrobial susceptibility by broth microdilution.³³ For each drug tested, isolates were defined as susceptible, intermediate, or resistant according to cutoff points defined by the National Committee for Clinical Laboratory Standards.³⁴ Multidrug-resistant isolates were compared by pulsed-field gel electrophoresis after digestion with *Sma*I. The similarity of isolates was assessed by comparing the migration distances of the DNA fragments.³⁵ Paired serum samples were tested for IgG antibodies to human parainfluenza viruses 1, 2, and 3, adenovirus, and respiratory syncytial virus by enzyme immunoassay.³⁶

Statistical Analysis

The data were analyzed with Epi Info³⁷ software. Relative risks and 95 percent confidence intervals were calculated³⁸ and adjusted by the Mantel-Haenszel method.³⁹ P values were calculated with Fisher's two-tailed exact test. To evaluate transmission between residents, we used a binomial probability model to compare the expected number of double-occupancy rooms with zero, one, or two colonized residents with the observed number by the chi-square statistic (goodness-of-fit test).

Interventions

On February 17, pneumococcal polysaccharide vaccine was given to 71 nonhospitalized residents who had no documentation of prior vaccination. Eleven employees with chronic illnesses were also vaccinated.⁴⁰ Because there were four additional cases of pneumonia during the next three days, all residents were given penicillin (500 mg three times daily) or ofloxacin (400 mg twice a day for 12 residents with penicillin allergy) for one week beginning on February 20. Penicillin was chosen on the basis of the initial susceptibility results, concern about drug interactions with other agents, and the lack of available data at that point regarding the susceptibility of the outbreak strain to other orally administered antibiotics. Although no susceptibility data for ofloxacin were available, it was chosen as the alternative on the basis of its good safety profile and the low prevalence of resistance in the United States.¹⁸ Two employees who were colonized with the outbreak strain received a combination of rifampin (600 mg daily) and ofloxacin (400 mg twice daily) for one week.

RESULTS

Epidemiologic Characteristics of the Outbreak

The nursing home in which the outbreak occurred is a 100-bed, single-story building with two wings. The members of the nursing staff frequently work on both wings. The 84 residents at the time of the outbreak ranged in age from 48 to 101 years (median, 85). Ninety-two percent were at least 65 years old; 81 percent were women, and 93 percent were white. There were 78 employees (median age, 41 years).

During the outbreak, 11 residents had illness that met the case definition, giving an attack rate of 13 percent (Fig. 1). The 11 patients were similar to residents who were not ill in mean age, race, and sex. All 11 patients had lobar consolidation evident on chest radiography, and none had symptoms suggestive of meningitis. Multidrug-resistant *S. pneumoniae*, serotype 23F, was isolated from the blood of four patients and from the respiratory tract of three (Table 1). Three patients, all with bacteremia, died (case fatality rate, 27 percent). Only 3 residents (4 percent) had had pneumococcal vaccination, although 60 of the 84 residents (71 percent) had received influenza virus vaccine during the fall of 1995. No cases were identified among the nursing staff.

Studies of Nasopharyngeal Carriage

Before any interventions were undertaken, the outbreak strain was isolated from nasopharyngeal specimens from 17 of the 74 residents tested (23 percent), including 3 in whom pneumonia subsequently developed, and 2 of the 69 employees tested (3 percent). All other pneumococcal isolates that were recovered were sensitive to penicillin (Table 2). In the second nasopharyngeal-culture survey, conducted after the completion of chemoprophylaxis, serotype 23F was recovered from three residents and none of the employees. Five weeks later, two residents were still colonized. All multidrug-resistant isolates from blood, sputum, and nasopharyngeal specimens

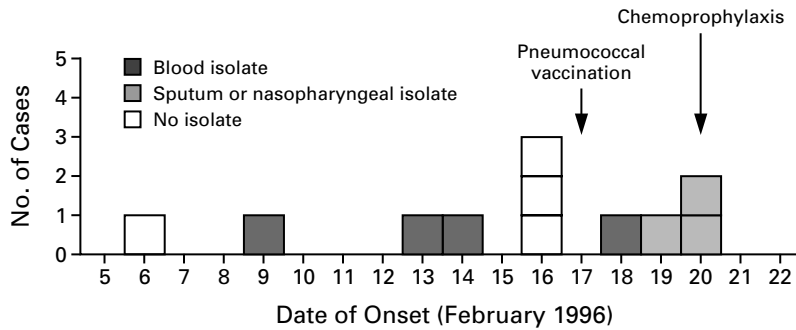


Figure 1. Cases of Pneumonia among Nursing Home Residents According to the Date of Onset of Illness. Blood isolate denotes that multidrug-resistant *S. pneumoniae* serotype 23F was isolated from the blood; sputum or nasopharyngeal isolate, that multidrug-resistant *S. pneumoniae* serotype 23F was isolated from the respiratory tract; and no isolate, that cultures were negative or were not done (one case).

had identical patterns of antimicrobial susceptibility (Table 3) and were indistinguishable from one another by pulsed-field gel electrophoresis (Fig. 2).

In the community, *S. pneumoniae* was isolated from nasopharyngeal specimens from 62 percent of 97 children tested. Two children, 18 and 20 months old, carried multidrug-resistant serotype 23F that was identical to the outbreak strain according to pulsed-field gel electrophoresis. However, they had no known contact with each other or with the nursing home. No invasive disease developed in any of the children participating in the nasopharyngeal survey.

Risk Factors for Colonization and Disease

Seventy-eight residents were enrolled in the cohort study; 25 were considered colonized with the outbreak strain (11 patients and 14 asymptomatic carriers). The colonization rates (64 percent vs. 28 percent; relative risk, 2.3; 95 percent confidence interval, 1.3 to 4.2) and attack rates of disease (36 percent vs. 10 percent; relative risk, 3.6; 95 percent confidence interval, 1.2 to 10.8) were higher among residents who were taking antibiotics at the time of onset of illness (or at the time of culturing, for residents who were not ill) than among those who had not taken antibiotics within the previous two months. However, there were no significant differences in the frequency of antibiotic use in the two months before the outbreak between colonized and noncolonized residents or between those who were ill and those who were not ill. Although the serum level of IgG antibodies to respiratory syncytial virus in one patient rose to four times the initial level (Patient 10 in Table 1), antecedent respiratory illness within two weeks was not associated with colonization or disease. Disease was more likely to develop in residents who had been hospitalized in the previous year (26 percent vs. 8 percent; relative risk, 3.3;

95 percent confidence interval, 1.1 to 10.3), who had had pneumonia in the previous year (67 percent vs. 12 percent; relative risk, 5.6; 95 percent confidence interval, 2.0 to 15.2), or who needed assistance when taking oral medications (28 percent vs. 8 percent; relative risk, 3.7; 95 percent confidence interval, 1.2 to 11.5). Colonization and attack rates were similar among residents of each wing and among residents in single-occupancy and double-occupancy rooms. On the basis of the binomial probability model, there was no clustering of colonized residents in double rooms. None of the colonized residents had had child visitors after January 1, 1996.

Analysis of interactions between the staff and residents identified two bedridden patients and two other patients who lived in single rooms and had had no contact with other residents or visitors after January 1. Both colonized employees provided direct patient care. Between January 1 and February 17, one was in charge of administering medications to every resident on both wings twice per shift. From January 18 to February 13, she had a febrile respiratory illness that was treated with amoxicillin, but she continued working while ill.

DISCUSSION

In this explosive outbreak, a single multidrug-resistant pneumococcal strain was disseminated among nursing home residents and staff members. Our investigation suggests that several factors contributed to the high attack rate of disease, including a susceptible, unvaccinated population and a high prevalence of colonization with a virulent organism. The epidemic ceased abruptly and carriage was reduced substantially after the administration of antibiotics and pneumococcal vaccine to residents.

Multidrug-resistant *S. pneumoniae* has become common worldwide,^{16,18,41,42} and serotype 23F, one

TABLE 1. DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF NURSING HOME RESIDENTS WITH PNEUMONIA.*

| PATIENT No. | AGE (YR)/SEX | DATE OF ONSET | CLINICAL SYNDROME† | SOURCE OF MULTIDRUG-RESISTANT ISOLATE | WHITE-CELL COUNT (CELLS/MM ³) | RECEIVED ANTIBIOTICS BEFORE CULTURE | UNDERLYING CONDITION | INITIAL THERAPY | OUTCOME |
|-------------|--------------|---------------|---------------------------------|---------------------------------------|---|-------------------------------------|-----------------------------|---|--------------|
| 1 | 89/F | 2/9/96 | Bibasilar pneumonia, bacteremia | Blood | 10,300 | No | CHF | Intravenous cefuroxime | Died 2/13/96 |
| 2 | 88/F | 2/13/96 | Bilateral pneumonia, bacteremia | Blood | 25,900 | No | DM | Intravenous ceftriaxone Intravenous vancomycin | Lived |
| 3 | 81/F | 2/14/96 | Bilateral pneumonia, bacteremia | Blood, sputum | 19,900 | No | None | Intravenous cefuroxime | Died 2/15/96 |
| 4 | 91/F | 2/16/96 | RUL pneumonia | No isolate | 17,800 | Yes | COPD, renal disease | Intravenous ceftriaxone Intravenous vancomycin | Lived |
| 5 | 86/M | 2/16/96 | LUL pneumonia | No isolate | 6,400 | Yes | DM | Intravenous ceftriaxone Intravenous vancomycin | Lived |
| 6 | 78/F | 2/16/96 | LLL pneumonia | No isolate‡ | 12,500 | Yes | Cirrhosis | Intravenous ceftriaxone Intravenous vancomycin | Lived |
| 7 | 81/M | 2/18/96 | LLL pneumonia, bacteremia | Blood | 34,800 | No | CHF, corticosteroid therapy | Intravenous ceftriaxone | Died 2/19/96 |
| 8 | 92/F | 2/19/96 | RLL pneumonia | Sputum, NP culture | 19,300 | Yes | CHF, DM | Intravenous ceftriaxone Intravenous vancomycin | Lived |
| 9 | 82/F | 2/20/96 | RLL pneumonia | NP culture | 24,600 | Yes | CHF | Intravenous ceftazidime Intravenous vancomycin | Lived |
| 10 | 100/F | 2/20/96 | LLL pneumonia | Sputum, NP culture | 16,200 | No | None | Intravenous ceftazidime Intravenous vancomycin | Lived |
| 11 | 79/F | 2/6/96 | RLL pneumonia | No cultures done§ | NA | NA | None | Oral cefprozil | Lived |

*CHF denotes congestive heart failure, DM diabetes mellitus, RUL right upper lobe, COPD chronic obstructive pulmonary disease, LUL left upper lobe, LLL left lower lobe, RLL right lower lobe, NP nasopharyngeal, and NA not available.

†All 11 patients had lobar or multilobar consolidation evident on chest radiography, with a compatible clinical syndrome. None had symptoms suggestive of meningitis (e.g., headache, focal cerebral signs, seizures, or meningismus); no lumbar punctures were performed.

‡Patient 6 was confirmed as having multidrug-resistant *S. pneumoniae* serotype 23F disease by an increase of IgG antibody titers to *S. pneumoniae* serotype 23F to four times the initial level, in paired acute-phase and convalescent-phase serum specimens in an enzyme-linked immunosorbent assay; she did not receive pneumococcal vaccine.

§Patient 11 was treated as an outpatient before the investigation began.

of the most common multidrug-resistant serotypes in the United States,^{43,44} has been associated with outbreaks in day-care centers^{17,24,45-47} and a pediatric long-term care facility.³¹ Although the rate of sporadic pneumococcal disease among nursing home residents is almost 14 times as high as that among the noninstitutionalized elderly,¹⁴ outbreaks have rarely been reported.^{12,13} Unrecognized or unreported clusters of cases of pneumococcal disease in nursing homes may be more common than is currently believed, because there is no routine surveillance for respiratory infections. These infections are commonly treated empirically, without microbiologic confirmation of their cause,⁴⁸⁻⁵⁰ and they generally respond promptly to empirical therapy. With the emergence of multidrug-resistant strains, clusters may become more noticeable if the rate of response to empirical therapy declines.

Our findings in an elderly population confirm those of several other studies that have associated prior antimicrobial use with colonization by resistant pneumococci in children^{17,21,24,31,46} and with drug-resistant

disease in children^{51,52} and adults.²⁶ Because of common^{50,53,54} and sometimes inappropriate^{49,50,55,56} antibiotic use, nursing homes may serve as foci for the emergence of drug-resistant bacteria. Residents who are frequently transferred to and from acute care hospitals may also provide a route for the spread of resistant strains from one susceptible population to another. Encouraging the judicious use of antibiotics is an important preventive strategy in institutional settings, where the potential for transmission and outbreaks is high.^{9,21,23-25,30}

Although the dynamics of *S. pneumoniae* colonization among institutionalized populations have not been well described, transmission from hospital staff to patients has been suggested.^{57,58} Exactly how and when the epidemic strain was introduced into the nursing home we studied is unknown, but two findings suggest person-to-person transmission from staff members to residents. First, the patients with pneumonia and the carriers were randomly distributed in the facility, so there was no pattern of transmission from colonized roommates. Second, contact with

TABLE 2. NASOPHARYNGEAL CARRIAGE OF *S. PNEUMONIAE* AMONG NURSING HOME RESIDENTS AND EMPLOYEES IN THREE CONSECUTIVE CULTURE SURVEYS, FEBRUARY AND MARCH 1996.

| GROUP | BEFORE INTERVENTION* | AFTER INTERVENTION | 5-WEEK FOLLOW-UP |
|---|----------------------|--------------------|------------------|
| | (2/17/96) | (2/28/96) | (3/26/96) |
| | number (percent) | | |
| Residents | | | |
| Tested | 74 | 68 | 71 |
| Carriers of any <i>S. pneumoniae</i> | 20 (27) | 3 (4) | 3 (4) |
| Carriers of multidrug-resistant <i>S. pneumoniae</i> serotype 23F | 17 (23)† | 3 (4)‡ | 2 (3)§ |
| Nursing staff | | | |
| Tested | 69 | 59 | 52 |
| Carriers of any <i>S. pneumoniae</i> | 12 (17) | 3 (5) | 3 (6) |
| Carriers of multidrug-resistant <i>S. pneumoniae</i> serotype 23F | 2 (3) | 0¶ | 0 |

*Pneumococcal polysaccharide vaccine was administered immediately after nasopharyngeal specimens were collected on February 17, 1996. Residents were given antibiotics from February 20 to February 27.

†Pneumonia developed in three of these residents after nasopharyngeal specimens had been collected.

‡Two of these three carriers had not been carriers before the intervention. P=0.01 for the comparison of numbers of carriers before and after intervention (by paired McNemar test).

§The outbreak strain was recovered from one of these residents before intervention but not immediately after intervention; the other resident was found to be colonized with the outbreak strain in all three nasopharyngeal surveys.

¶Only two employees who were colonized with the outbreak strain were treated with antibiotics (from March 1 to March 7); new cultures were obtained from them on March 11. Eleven employees with chronic illnesses were vaccinated on February 17.

colonized nursing staff was the only potential source of exposure for two bedridden patients, who were not exposed to other residents or visitors.

The rate of asymptomatic carriage among residents (23 percent) was higher than that generally reported among adults (less than 10 percent).^{4,7-9,12,13} The available data on the effect of antibiotics on rates of pneumococcal colonization in adults are limited and inconclusive^{6,9,59} and do not pertain to penicillin-resistant strains or the elderly. In children, attempts to eliminate drug-resistant pneumococci from the respiratory tract with antibiotics have generally been unsuccessful and have resulted in rapid recolonization.^{21,23,24,60} Therefore, the goal of chemoprophylaxis in our intervention was not to eradicate carriage but rather to provide some protection while vaccine-induced immunity was developing. After the administration of vaccine and antibiotics, no new cases occurred. Surprisingly, carriage was also reduced substantially despite the strain's resistance to penicillin, and no recolonization occurred during follow-up. However, it is not possible to distinguish the separate effects of antibiotics and vaccination in ending the outbreak.

Although pneumococcal polysaccharide vaccine has not been shown to reduce carriage in children,⁶¹

TABLE 3. MINIMAL INHIBITORY CONCENTRATIONS OF VARIOUS ANTIBIOTICS AGAINST 33 MULTIDRUG-RESISTANT ISOLATES OF *S. PNEUMONIAE* SEROTYPE 23F.*

| DRUG | MINIMAL INHIBITORY CONCENTRATION | SUSCEPTIBILITY OF ISOLATES |
|-------------------------------|----------------------------------|----------------------------|
| | $\mu\text{g/ml}$ | |
| Penicillin | 2 | Resistant |
| Cefotaxime | 2 | Resistant |
| Cefaclor† | ≥ 16 | |
| Meropenem† | 0.5 | |
| Trimethoprim-sulfamethoxazole | 4-76 | Resistant |
| Erythromycin | ≥ 8 | Resistant |
| Ofloxacin | 2 | Susceptible |
| Tetracycline | ≥ 32 | Resistant |
| Chloramphenicol | 16 | Resistant |
| Clindamycin | ≥ 8 | Resistant |
| Rifampin | ≤ 0.5 | Susceptible |
| Vancomycin | ≤ 0.5 | Susceptible |

*The data are from 4 blood, 3 sputum, and 22 nasopharyngeal isolates from nursing home residents, 2 nasopharyngeal isolates from nursing home staff, and 2 nasopharyngeal isolates from children in the community. The interpretive criteria for susceptibility use cutoff points defined by the National Committee for Clinical Laboratory Standards.³⁴

†No official interpretive guidelines for nonsusceptibility have been published.

one study in adults reported reduced colonization rates after vaccination,⁶² and an institutional outbreak during the preantibiotic era ended abruptly after residents were vaccinated.⁶³ Vaccination and chemoprophylaxis may both have had a role in reducing carriage. Successful eradication of the organism from the two colonized employees by antibiotics may have eliminated the most likely source of reinfection in this relatively closed environment.

The optimal strategy for controlling drug-resistant pneumococcal outbreaks in nursing homes and other institutions needs to be determined. When possible, grouping of ill patients and exposed staff (cohorting) and closing the facility to new admissions are reasonable while there is ongoing transmission. However, performing nasopharyngeal-culture surveys and isolating colonized residents are generally not feasible. The part that colonized staff members appear to have played in spreading the outbreak strain highlights the importance of keeping health care providers away from nursing homes when they are ill. The decision to administer chemoprophylaxis in an outbreak caused by drug-resistant pneumococci should be made on a case-by-case basis, while taking into consideration the attack rate, whether transmission is ongoing, the susceptibility pattern of the isolate, and the potential for the development of resistance.^{64,65}

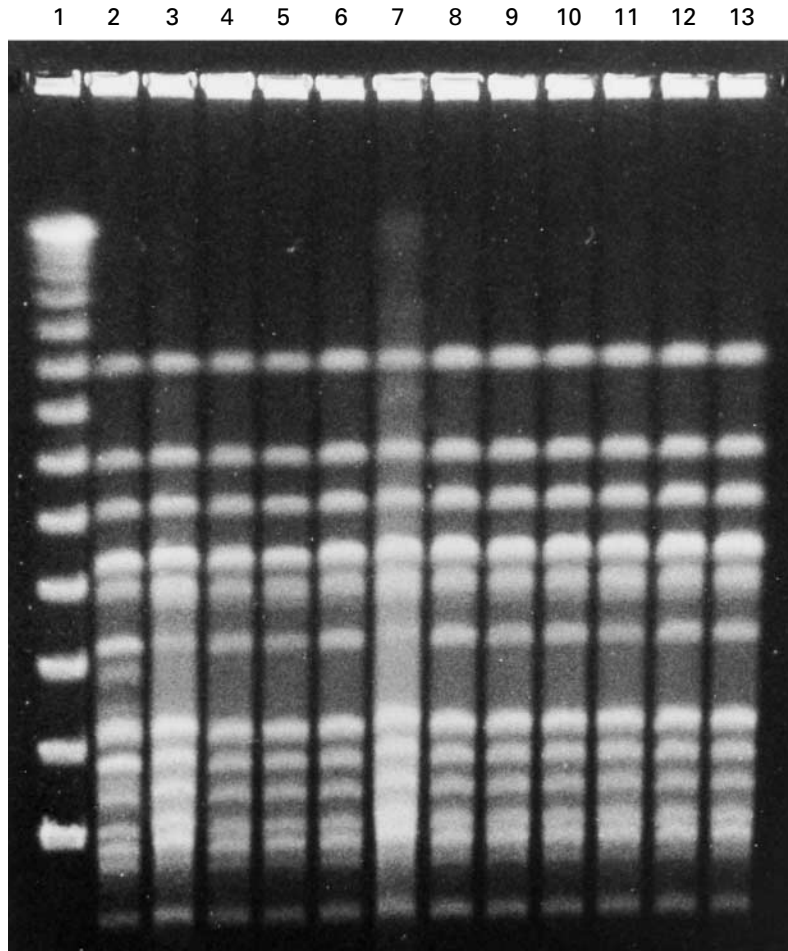


Figure 2. Pulsed-Field Gel Electrophoretic Patterns of 12 Isolates of Multidrug-Resistant *S. pneumoniae*, Serotype 23F.

Lane 1 shows the DNA molecular-size standard (lambda ladder); lanes 2 and 3, nasopharyngeal isolates from two children in the community; lanes 4, 5, and 6, blood isolates from the three nursing home residents in the initial cluster; lanes 7 and 8, nasopharyngeal isolates from two colonized nursing home employees; and lanes 9 to 13, five randomly selected nasopharyngeal isolates from asymptomatic colonized residents. The enzyme used for DNA digestion was *Sma*I.

S. pneumoniae is the most common cause of nursing home-acquired pneumonia.⁶⁶ The potential of resistant strains to cause epidemic disease, with high case fatality rates among unvaccinated persons who are susceptible because of the absence of antibodies,⁶⁷ underscores the importance of prevention by vaccination. Although the data on the efficacy of pneumococcal vaccine in preventing nonbacteremic pneumonia are inconclusive,^{68,69} and although its efficacy in preventing bacteremia may be limited in the very old,⁷⁰ the vaccine is efficacious and cost effective in reducing the overall incidence of pneumococcal bacteremia in the elderly.⁷⁰⁻⁷³ However, only 30 percent of persons 65 years of age or older have been vaccinated,⁷⁴ and in all reported nursing home outbreaks less than 5 percent of residents had been vaccinated.^{12,13} All but six of the residents of the

nursing home had indications for pneumococcal vaccination, but only three had documented prior vaccination.

Factors contributing to the underuse of pneumococcal vaccine in nursing homes may include a low priority assigned to the problem among physicians, skepticism about the effectiveness of the vaccine, difficulties in determining the residents' vaccination history, and concern about adverse reactions after unintended revaccination.^{12,13} However, revaccination is not associated with an increased incidence of serious adverse events.⁷⁵ In view of the lack of effective means to reduce or prevent transmission, the possible increase in pneumococcal outbreaks,¹³ and the continuing emergence of drug resistance,¹⁸ nursing homes should offer pneumococcal vaccine to all eligible residents and to new residents on admission

to the facility. All persons 65 or older should be vaccinated if their vaccination status is unknown.⁴⁰ Improved vaccine coverage among the 1.38 million elderly people living in U.S. nursing homes⁷⁶ should be the foundation for preventing outbreaks of pneumococcal disease in long-term care facilities.

Presented in part at the 35th Interscience Conference on Antimicrobial Agents and Chemotherapy, New Orleans, September 15–18, 1996.

We are indebted to the following persons for their assistance in the investigation: Donna Erickson, Jackie Turnbull, and Chris Manschreck, McAlester Regional Health Center, McAlester, Oklahoma; Michael Echelle, Pittsburg County Health Department, McAlester, Oklahoma; Denise Robinson, University of Oklahoma Health Sciences Center, Oklahoma City; and Robert Breiman, George Carlone, Sandra Steiner, Tamar Kvaratskhava, Dean Erdman, Steve Monroe, Roger Glass, and Richard Facklam, Centers for Disease Control and Prevention.

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